GSHPs at Disposal Sites

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GSHPs at Remedial Sites
Concepts to Consider

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Today's Topics

- Direct Use of GSHPs for HVAC
- General Care and Feeding of GSHPs
- Concept I: Convenient Co-location of GSHPs at Remedial Sites
- Concept II: GSHPs for Remedial Enhancement *or Deciding to Go Down the Rabbit Hole*

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You do not need a volcano for Geothermal HVAC

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Direct Use of GSHPs at Remedial Sites

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‘Traditional’ Use of GSHPs for HVAC

- GSHPs use the Earth as a source of heating, cooling and process water
- ***Moves*** free energy instead of creating heat through burning expensive fuel
- Releases or absorbs heat from the ground

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Use of Groundwater Recovery as the Ground-Source

- GSHPs use the remedial process water for heat extraction or rejection
- Still ***Moves*** thermal energy and may be more efficient because of higher source temperature
- Has been done at sewage treatment plants
- Has been evaluated at Baird-McGuire

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Care and Feeding of GSHPs

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GSHP Design Preferences

- Intermittent operation when there is an HVAC Demand
- Available source water flow, typically 2.5 - 3 GPM/Ton
- Source and load water quality requirements
- Maximum flow velocities are typically less than 6 ft/sec. to avoid erosion of heat exchanger.
- Have a ground-source that meets or exceeds the HVAC demand for *long-term* (decades) stable source temperature

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Minimum Water Quality Requirements

- Can’t pump trash - not designed for high TSS
- Sensitive to corrosive conditions
- Protect against mineral precipitate and bio buildup
- Warranty keyed to water quality

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Example Water Quality Requirements

Material		Copper	90/10 Cupronickel	316 Stainless Steel
pH	**Acidity/Alkalinity**	7 - 9	7 - 9	7 - 9
Scaling	Calcium and Magnesium Carbonate	(Total Hardness) less than 350 ppm	(Total Hardness) less than 350 ppm	(Total Hardness) less than 350 ppm
Corrosion	Hydrogen Sulfide	Less than 0.5 ppm (rotten egg smell appears at 0.5 ppm)	10 - 50 ppm	Less than 1 ppm
	Sulfates	Less than 125 ppm	Less than 125 ppm	Less than 200 ppm
	Chlorine	Less than 0.5 ppm	Less than 0.5 ppm	Less than 0.5 ppm
	Chlorides	Less than 20 ppm	Less than 125 ppm	Less than 300 ppm
	Carbon Dioxide	Less than 50 ppm	10 - 50 ppm	10 - 50 ppm
	Ammonia	Less than 2 ppm	Less than 2 ppm	Less than 20 ppm
	Ammonia Chloride	Less than 0.5 ppm	Less than 0.5 ppm	Less than 0.5 ppm
	Ammonia Nitrate	Less than 0.5 ppm	Less than 0.5 ppm	Less than 0.5 ppm
	Ammonia Hydroxide	Less than 0.5 ppm	Less than 0.5 ppm	Less than 0.5 ppm
	Ammonia Sulfate	Less than 0.5 ppm	Less than 0.5 ppm	Less than 0.5 ppm
	Total Dissolved Solids (TDS)	Less than 1000 ppm	1000 - 1500 ppm	1000 - 1500 ppm
	LSI Index	+0.5 to -0.5	+0.5 to -0.5	+0.5 to -0.5
Iron Fouling (Biological Growth)	Iron, FE^{2+} (Ferrous) Bacterial Iron Potential	< 0.2 ppm	< 0.2 ppm	< 0.2 ppm
	Iron Oxide	Less than 1 ppm, above this level deposition will occur	Less than 1 ppm, above this level deposition will occur	Less than 1 ppm, above this level deposition will occur
Erosion	Suspended Solids	Less than 10 ppm and filtered for max. of 600 micron size	Less than 10 ppm and filtered for max. of 600 micron size	Less than 10 ppm and filtered for max. of 600 micron size
	Threshold Velocity (Fresh Water)	< 6 ft/sec	< 6 ft/sec	< 6 ft/sec

NOTES: Grains = ppm divided by 17
mg/L is equivalent to ppm

2/22/12

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Alternatives for Poor Water Quality

- Frequent Maintenance
- Scheduled Equipment Replacement
- Intermediate Heat Exchanger
  (still need maintenance)
- Closed Loop Configuration

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Other Considerations

- Load-side Design is as Important as Source-side
  - Refrigerant system operation requires load to accept the heating/cooling at the designed output.

- GHPSs are not Intrinsically Safe/XP
  - Need to consider operational location and may need hydronic method to move heated/chilled fluid to remedial zone

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Concept I:
Convenient Co-location

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Remedial Soil Excavation

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Excavation Considerations - Repeated

- Deeper is Better
  - GSHP piping should be at least 5 feet BGS
  - Deeper placement improves heat transfer
  - Placement in groundwater improves heat transfer

- GHPSs are not Intrinsically Safe/XP
  - Need to consider operational location and may need hydronic method to move heated/chilled fluid to remedial zone

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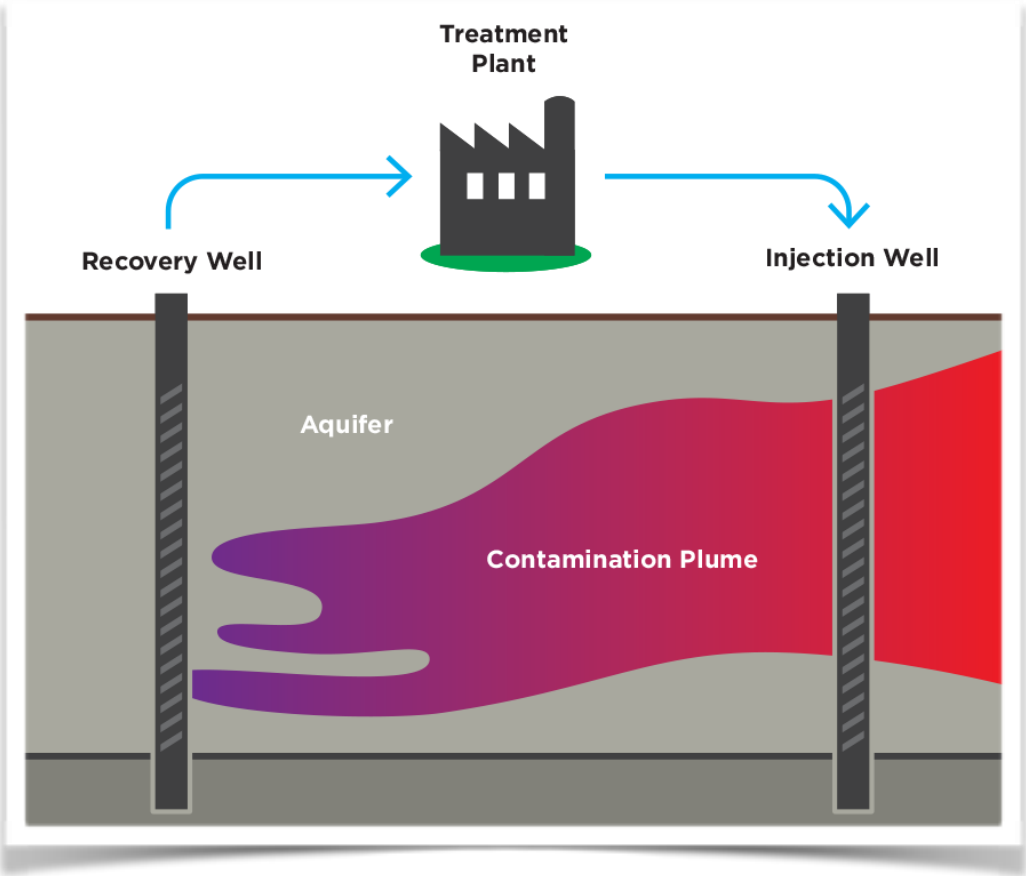
Direct Use:
Groundwater Pump and Treat



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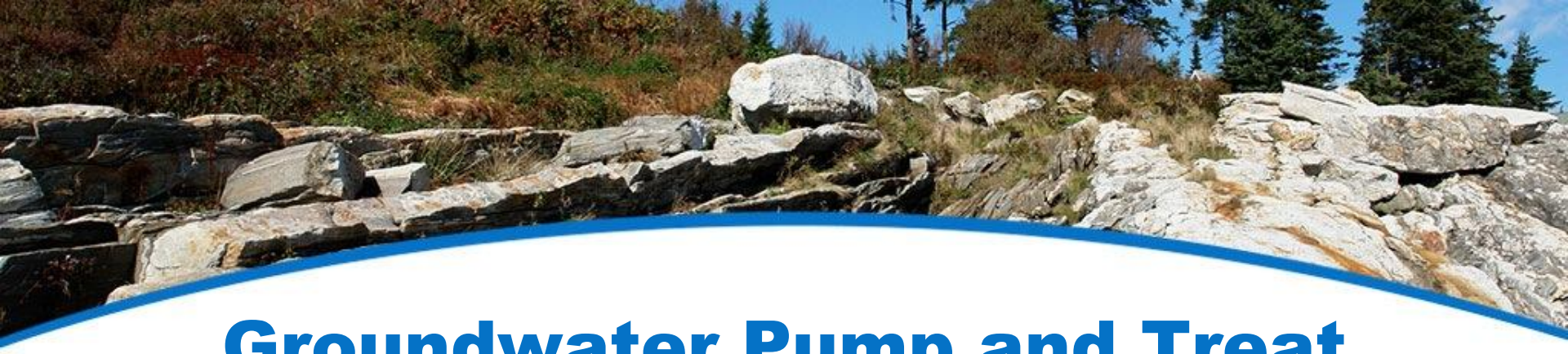

Groundwater Pump and Treat

- Use the existing flow of remedial system as source for GSHP
- Heating and/or cooling can be provided to loads such as remedial enclosure, proximal building other process water system.
- Alternatively, use a separate ground-source.

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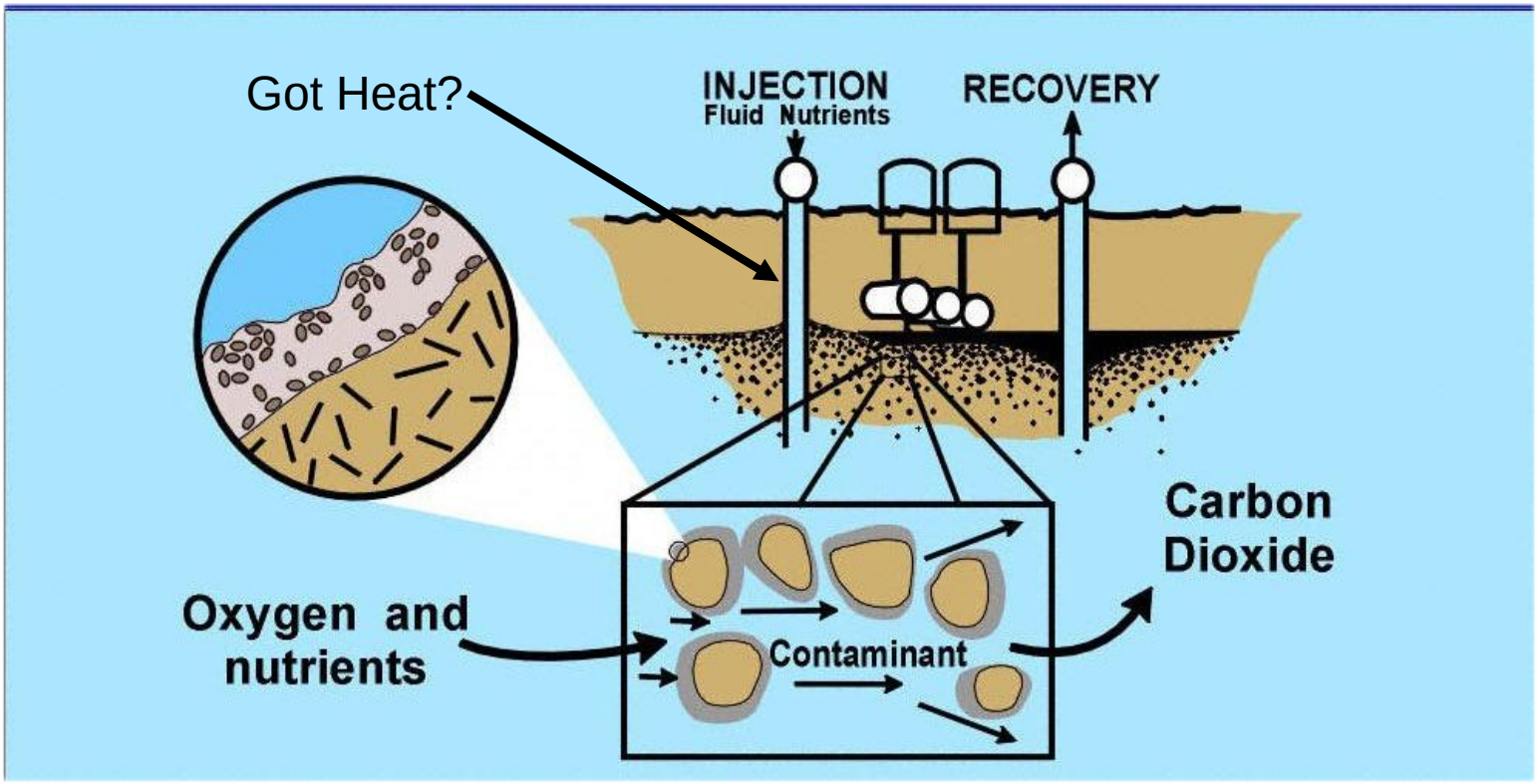
Bioremediation



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GSHPs and Bio

- Rule of Thumb: Microbial activity doubles with a 10 Deg. C. increase in temperature
- Cooling can be provided to loads such as remedial enclosure, proximal building, or other process water system.
- Alternatively, use a separate ground-source.

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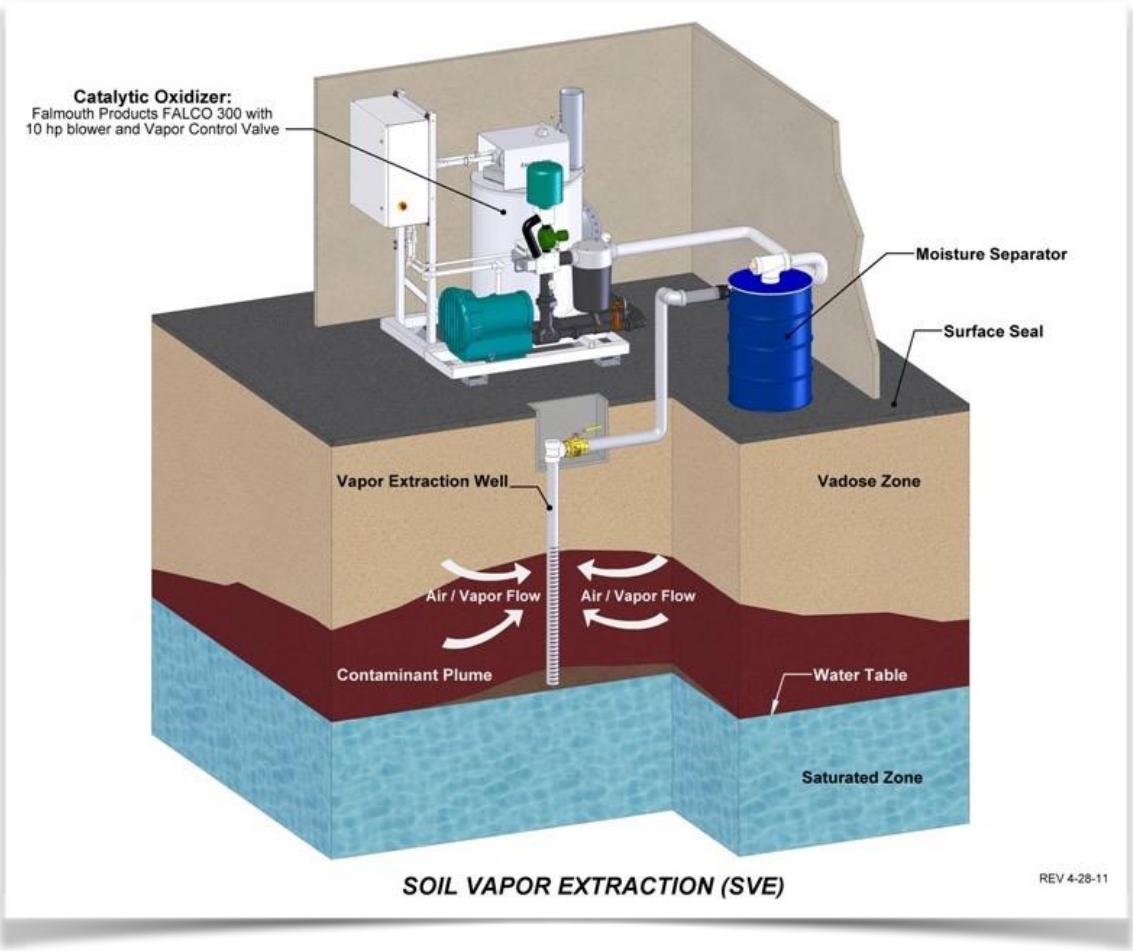
Soil Vapor Extraction



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SVE or Bio Co-location

- Consider horizontal closed loop where trenching is planned
- For current or future use
- Deeper is better than shallower
- Installation in or close to saturated zone is better than dryer soil

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Concept II: Remedial Enhancement with GSHPs

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Remedial Enhancement
Want to go Down the Rabbit Hole?

- Consider how moving heat from one part of the disposal site to another might enhance remedial effect.
- Would it be efficacious to increase or decrease microbial activity, volatilization, contaminant desorption at a Disposal Site?
- If so, do we use GSHPs under normal design conditions or do we go down the rabbit hole and push operating limits for heating/cooling outside of recommended ranges?
- If short-term temperature excursions are helpful for remedial enhancement, do we need to design for decades of stability?
- The ultimate limiting factor may be the operational range of the refrigerant used in the GSHP (usually R-410A).

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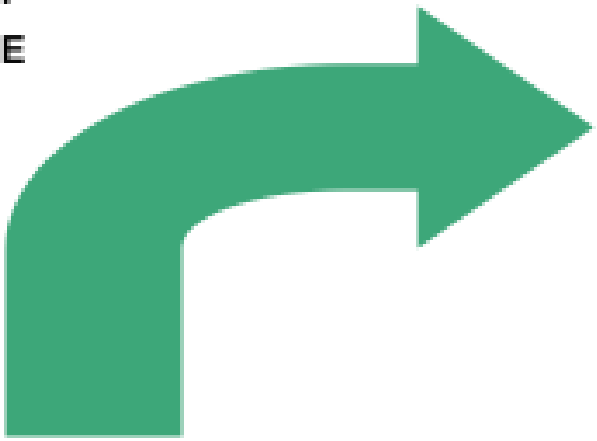
Geothermal Heating Cycle Efficiency

1 UNIT OF ENERGY
USED TO OPERATE



5 UNITS OF ENERGY
DELIVERED INTO HOME

4 UNITS OF RENEWABLE ENERGY
FROM THE EARTH

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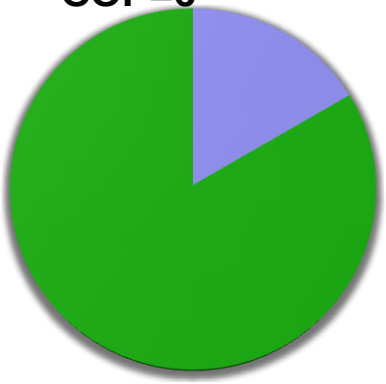
Comparison of Heating System Efficiencies

Electric COP=1

Bought
Lost
Free

Geothermal COP=6



Fuel Oil COP=0.75

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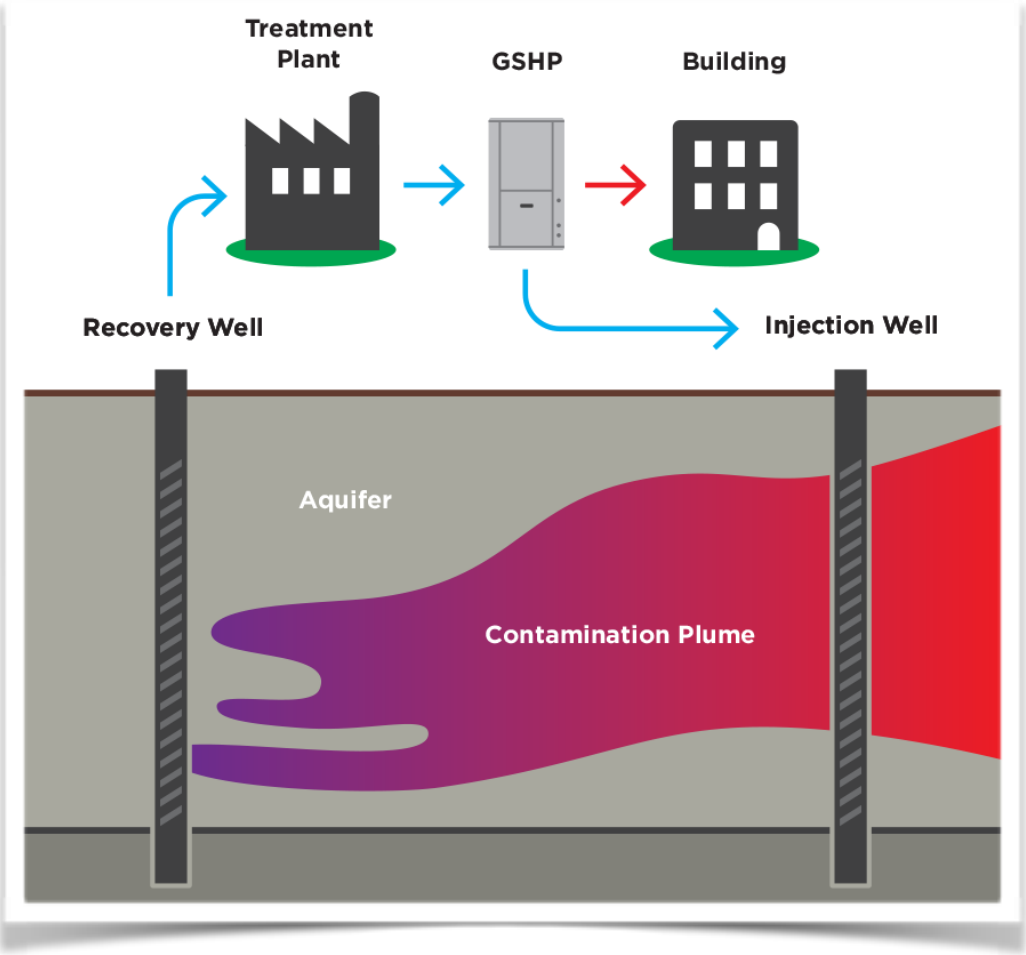
P&T or Bio



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Pump and Treat or Bioremediation

- Rule of thumb: Microbial respiration rate doubles with a 10 degree C increase in temperature
- Could use a separate ground-source to heat recovered groundwater before discharge
- Could use a closed-loop installation that is intentionally ‘too short’ and ‘too dense’ to heat soil in the treatment zone
- Could heat GW prior to air stripping to enhance volatilization

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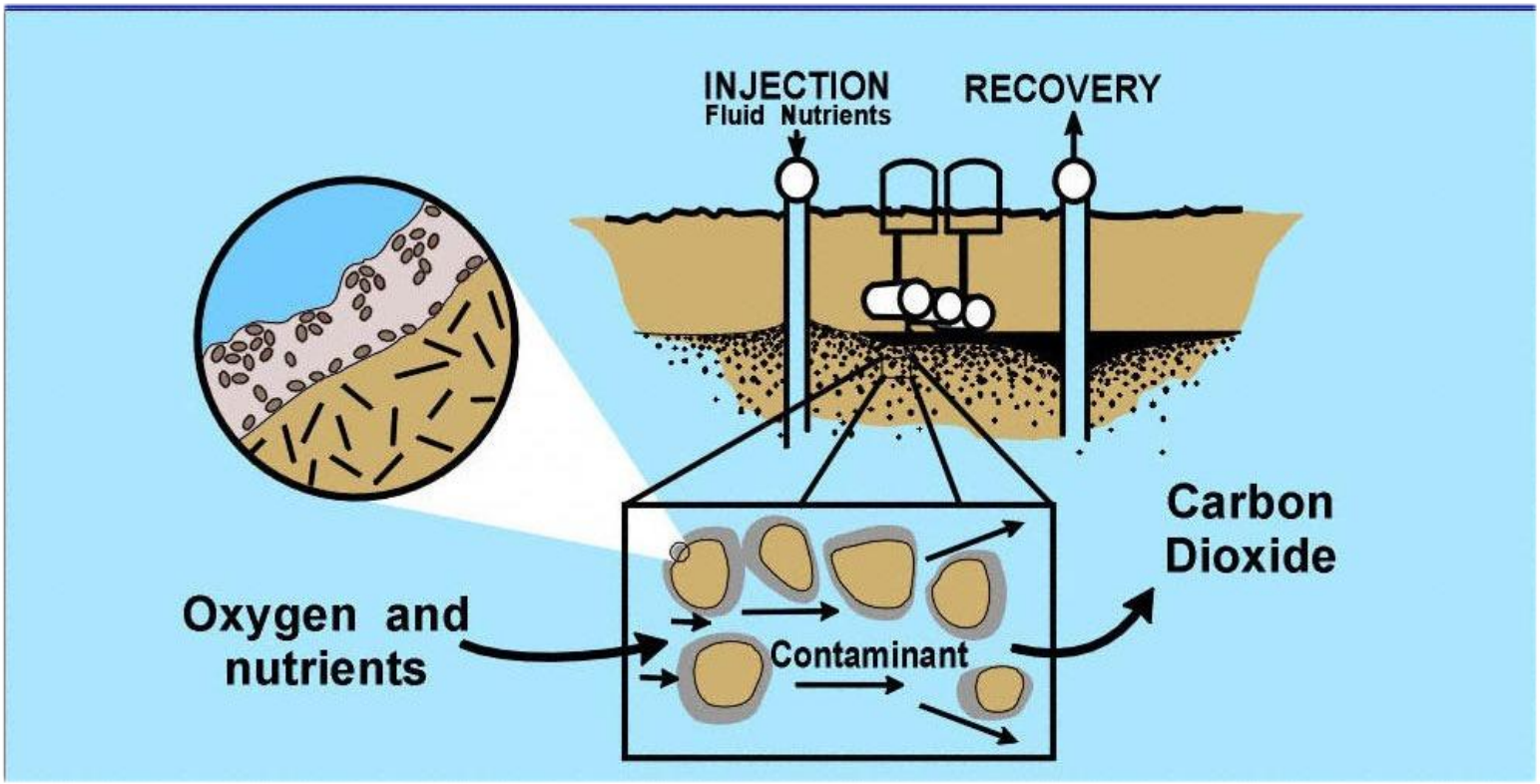
Bioremediation



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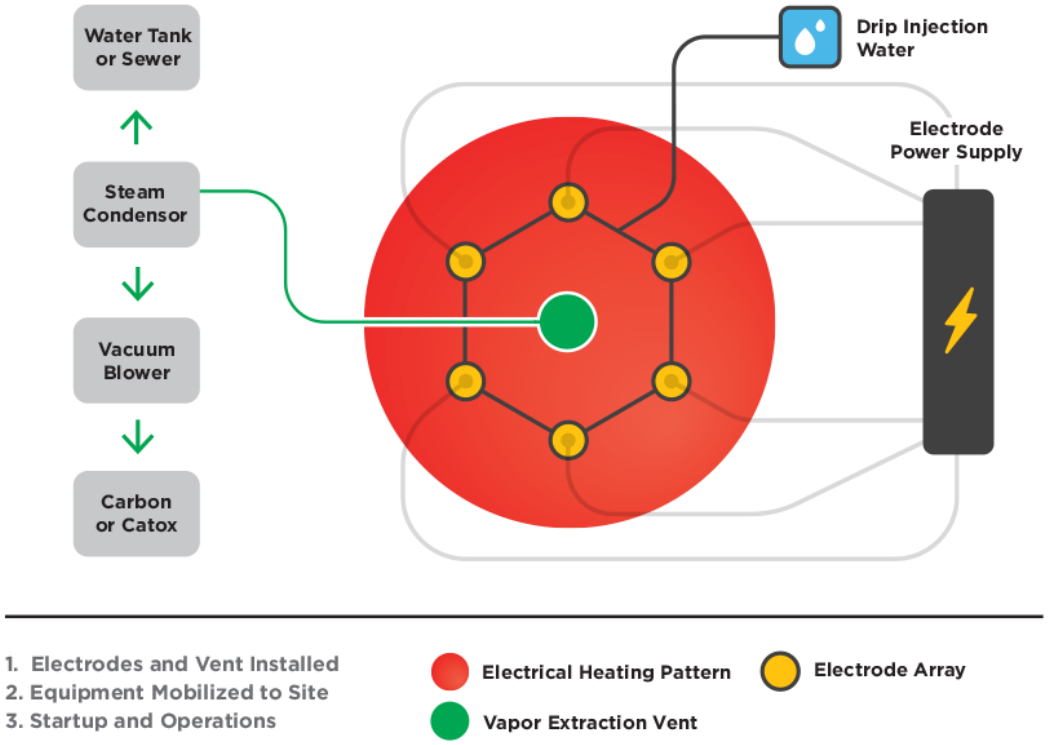
SVE and DPE

6 Ph. Heating used by firms like Terra Therm to enhance remedial effect.

Groundwater is often boiled generating steam



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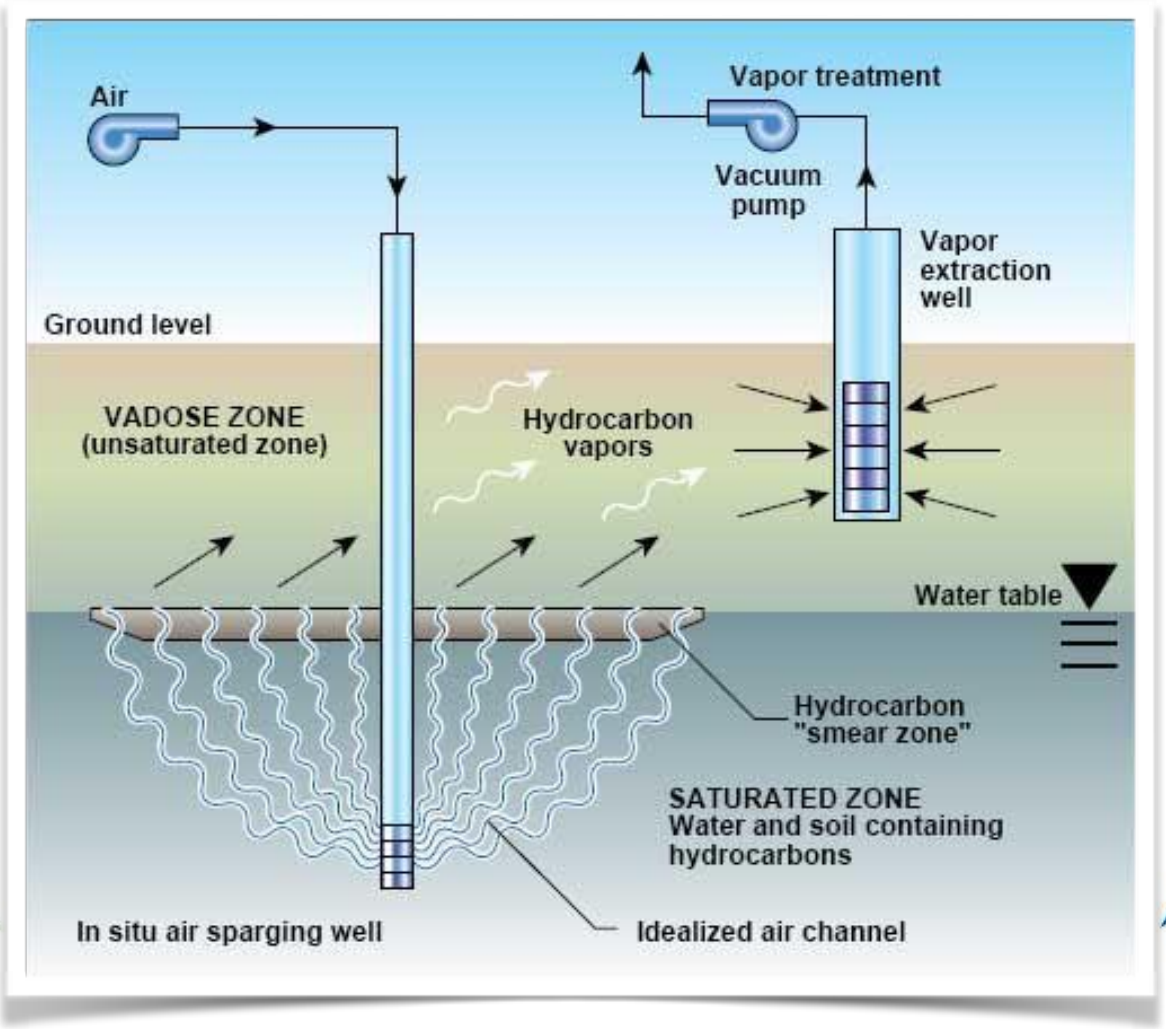
Traditional SVE/AS



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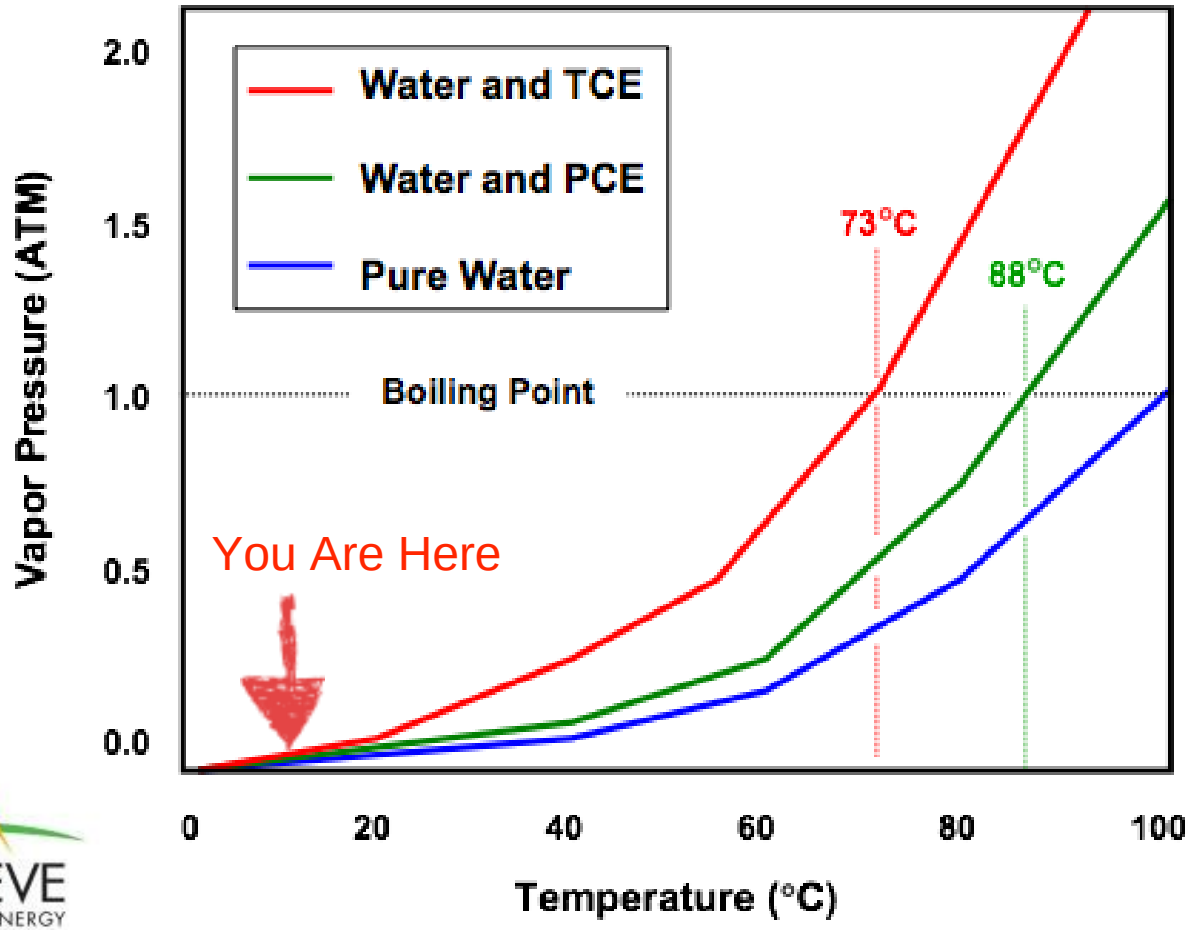
SVE is Limited by Volatilization Rate



Pure TCE
B.P. = 87°C

Pure PCE
B.P. = 121°C

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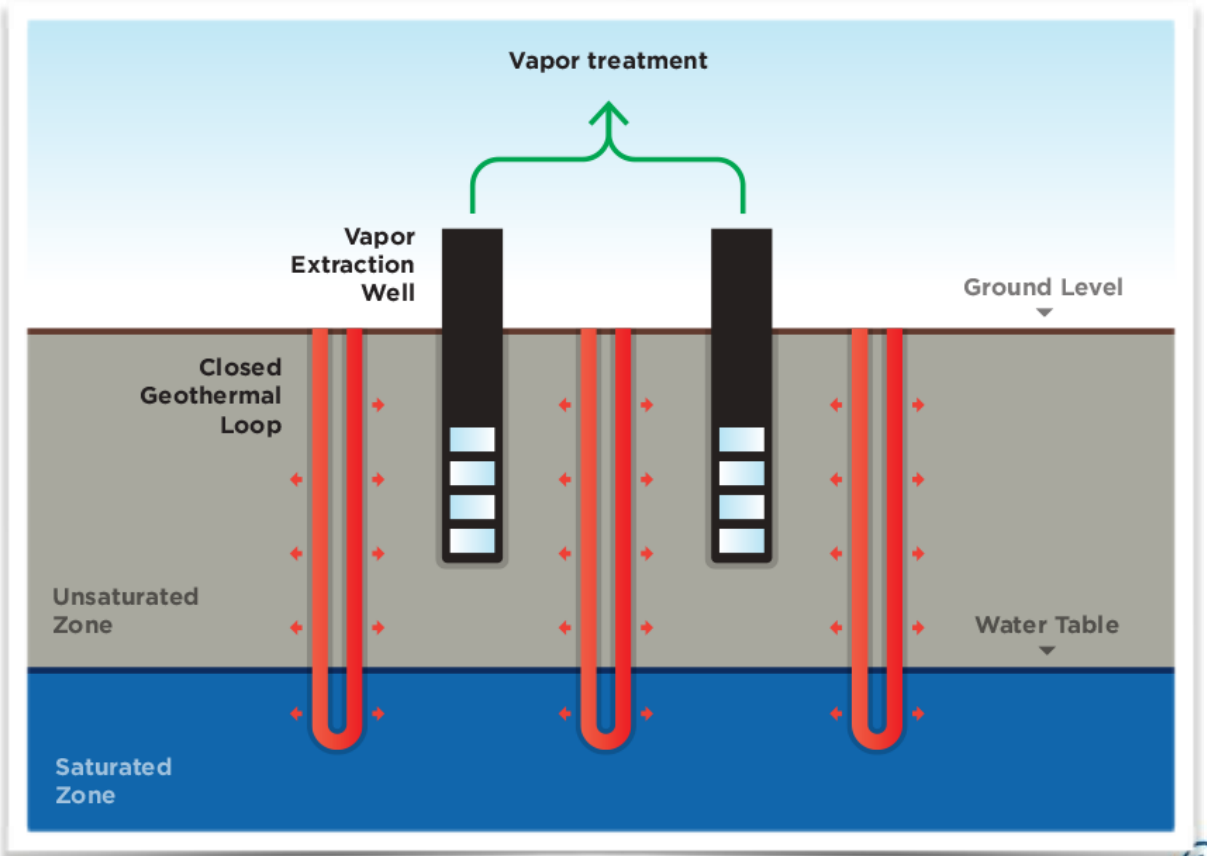
GSHP Heating



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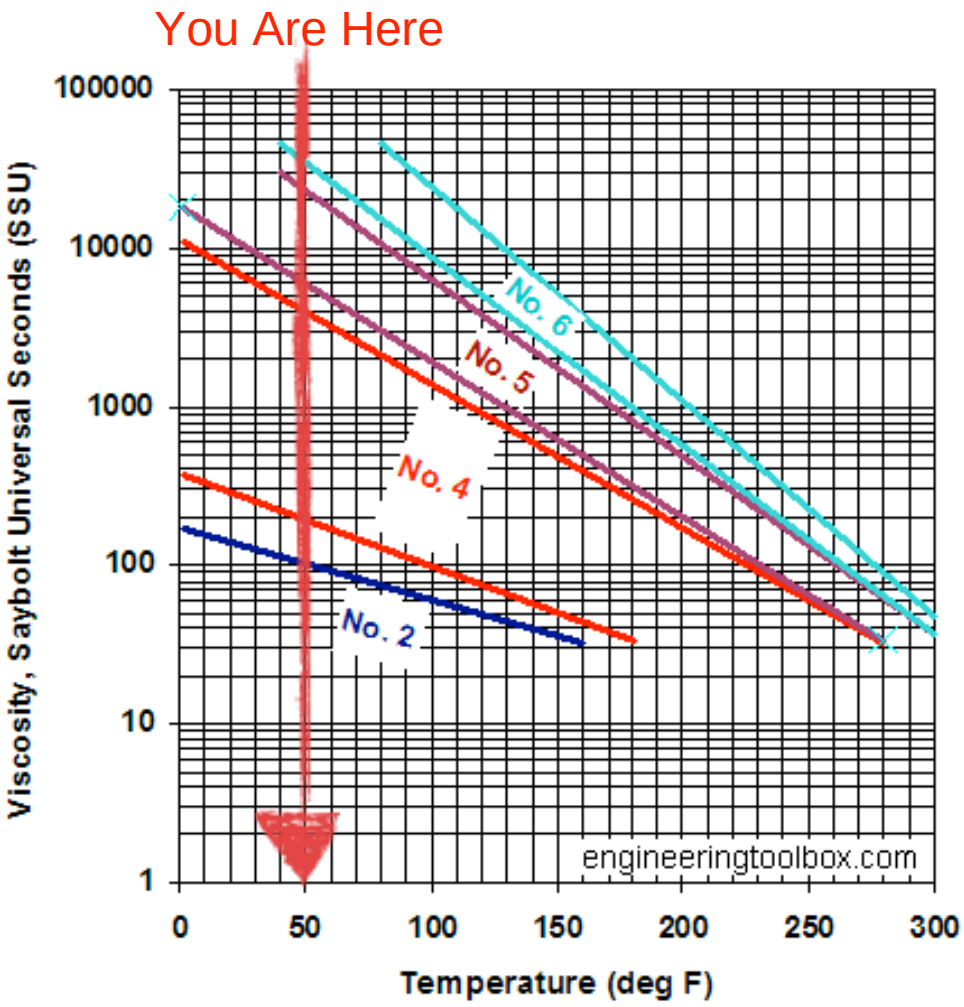
Oil Viscosity



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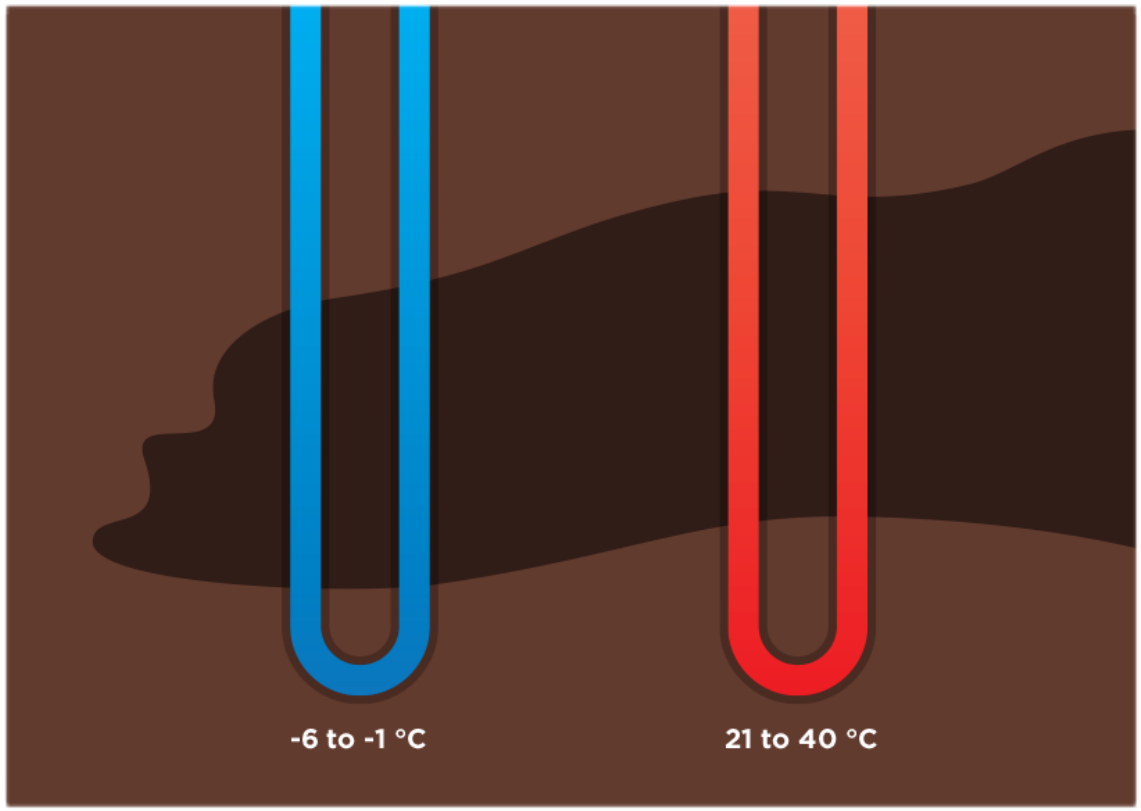
Change Migration Rates
Use Heat/Cold to Change Viscosity



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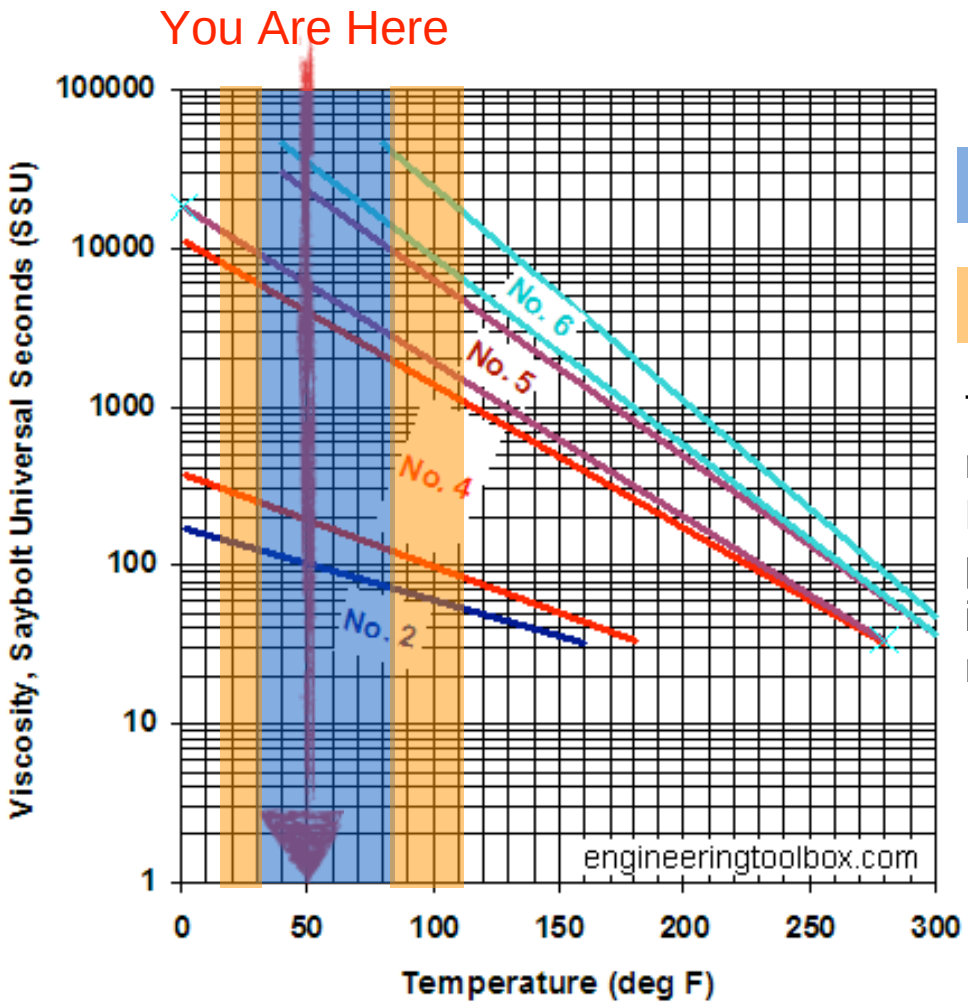

Normal GSHP Operation

Down the Rabbit Hole

The ‘Normal’ range is for reliable, unattended operation. Remedial actions can potentially tolerate, and often include, maintenance and monitoring.

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